United States Environmental Protection Agency **Office of Research and Development**

National Exposure Research Laboratory
Research Abstract
Government Performance Results Act Goal: Clean and Safe Water

Significant Research Findings:

Complete Total Maximum Daily Load (TMDL) Modeling Application and Sampling Procedures

Scientific Problem and Policy Issues

The Hydrologic Simulation Program - FORTRAN (HSPF) is a principal model currently recommended by the U.S. Environmental Protection Agency's Office of Water for watershed analyses for Total Maximum Daily Loads (TMDL) development (Bicknell *et al.* 1997). The research developed a new hydrodynamic and sediment transport model for HSPF which makes HSPF more versatile and comprehensive for evaluating sediment transport within stream/river networks. Sampling procedures for collecting the requisite sediment data for performing the sediment transport modeling have also been developed. This research contributes to the development of modeling protocols for sediment TMDLs in support of the Clean Water Act.

Research Approach

The existing sediment transport and flow routines in HSPF are simple routing modules and, as such, are limited to steady, uni-direction flows. The approach used to develop a new stand-alone one-dimensional (1-D) hydrodynamic and sediment transport model include:

1) developing and testing a stand-alone 1-D model which simulates the flow of water and transport of sediments,
2) developing a post-processing program for visualization of the simulated flows and changes in the stream bed resulting from deposition and/or scour of sediments,
3) incorporating the new 1-D hydrodynamic and sediment transport model into HSPF, and
4) describing the sampling procedures for collecting the sediment transport data necessary to perform sediment transport modeling in streams/rivers.

Results and Implications

The new hydrodynamic and sediment transport model, EFDC1D, the supporting post-processor, the integration of EFDC1D into HSPF, and sampling procedures for sediments in streams are briefly described below.

- EFDC1D — This is a new 1-D hydrodynamic and sediment transport model that can be applied to stream networks (Hamrick 2001). The model code, two sample data sets, and the User Manual are included on the distribution CD in Hayter *et al.* (2001). EFDC1D can simulate bi-directional unsteady flows and has the ability to accommodate unsteady inflows and outflows associated with upstream inflows, lateral inflows and withdrawals, groundwater/surface water interaction, evaporation, and direct rainfall. The model also includes representation of hydraulic structures such as dams and culverts. For sediment transport, the model includes settling, deposition, and resuspension of multiple size classes of cohesive and non-cohesive sediments. The bed is represented by multiple layers of mixed sediment classes. A bed consolidation model is used to predict time variations of bed depth, void ratio, bulk density, and shear strength. The sediment bed representation is dynamically coupled to the cross-sectional area representation to account for area changes due to deposition and resuspension.

- GenScn — The interactive computer program *GENeration and analysis of model simulation SCeNarios* (GenScn), developed by Kittle *et al.* (1998), was modified to read an EFDC1D output file containing simulated time series of parameters such as water surface elevation, temperature, salinity, discharge, cross-sectional area and wetted perimeter, concentrations of suspended cohesive and non-cohesive sediment, and average bed shear stress at each computational cell. Time series plots of these parameters can be generated for any computational cell. The modified version of GenScn is also included on the distribution CD.

- Another task in this project was to develop and integrate the ERDC1D hydrodynamic and sediment transport model into HSPF to provide a more valid flow/sediment transport modeling tool for development of TMDLs in watersheds that experience significant nonpoint source impacts. Integration of EFDC1D with HSPF is feasible, requiring additional study to determine the advisability and method of integration and requiring additional 1-D model code testing and refinement. A bridge or linkage program was developed to reformat the output of HSPF for input to the stand-alone EFDC1D model. This linkage program is also included on the distribution CD.

- To perform sediment transport modeling, a comprehensive set

of sediment data must be collected/measured in the water body to be modeled. A generic field study work plan, including sediment sampling procedures, is given as an example of the type of field study that should be performed to collect these data.

These models will be distributed and supported through the EPA Center for Exposure Assessment Modeling http://www.epa.gov/ceampubl.

These new modeling tools will be useful to states and EPA regions for developing sediment TMDLs for impaired streams and rivers.

Research Collaboration and Publications

Examples of recent publications from this study include:

Bicknell, B.R., Imhoff, J.C., Kittle, J.L., Jr., Donigian, A.S., Jr., and Johanson, R.C. "Hydrological Simulation Program - FORTRAN, User's Manual for Release 11" (EPA/600/R-97/080). U.S. Environmental Protection Agency, National Exposure Research Laboratory, Athens, GA. 1997.

Hayter, E.J., Hamrick, J.M., Bicknell, B.R., and Gray, M.H. "One-Dimensional Hydrodynamic/Sediment Transport Model for Stream Networks," *Technical Report,* U.S. Environmental Protection Agency, National Exposure Research Laboratory, Athens, GA. 2001.

Hamrick, J. "EFDC1D, A One Dimensional Hydrodynamic and Sediment Transport Model for River and Stream Networks - Model Theory and Users Guide," Tetra Tech, Inc., Fairfax, Virginia. 2001.

Kittle, J.L., Jr., Lumb, A.M., Hummel, P.R., Duda, P.B., and Gray, M.H. "A Tool for the Generation and Analysis of Model Simulation Scenarios for Watersheds (GenScn)," U.S. Geological Survey Water-Resources Investigations Report 98-4134, 1998.

Future Research

The integration of EFDC1D with HSPF should be undertaken if additional resources become available. Demonstration and evaluation of EFDC1D is planned by applying this model to the Housatonic River in Massachusetts in Fiscal Year 2002.

Contacts for Additional Information

Questions and inquiries can be directed to:

Earl J. Hayter, Ph.D.
US EPA, Office of Research and Development
National Exposure Research Laboratory
Athens, GA 30605-2700

Phone: 706/355.8303
E-mail: hayter.earl@epa.gov